

WHAT IS CLAIMED IS:

1. An endpoint device for use in a communication system wherein the endpoint device which has received an interrogating signal containing a main carrier and transmitted from an interrogator responds to the interrogator with a reflected signal which is generated by modulating the main carrier with appropriate information, said endpoint device comprising:
  - a distance detecting portion operable to detect a distance between said interrogator and said endpoint device;
  - a reflecting portion operable to receive and reflect said interrogating signal transmitted from said interrogator;
  - an information generating portion operable to generate replying information to be transmitted to said interrogator;
  - a band determining portion operable to determine, on the basis of said distance detected by said distance detecting portion, a frequency band of a modulating signal used to modulate a reflected signal generated by said reflecting portion; and
  - a modulating signal generating portion operable, according to said replying information generated by said information generating portion, to generate said modulating signal having a frequency within said frequency band determined by said band determining portion.
2. The endpoint device according to claim 1, wherein said band determining portion is operable to determine said frequency band such that a center frequency of the determined frequency band increases with a decrease in said distance detected by said distance detecting portion.
3. The endpoint device according to claim 1, wherein said band determining portion is operable to determine said frequency band on the basis of said distance detected by said distance detecting portion, and according to a predetermined equation representative of a relationship between said distance and frequency band.
4. The endpoint device according to claim 1, wherein said band determining portion is operable to determine said frequency band on the basis of said distance detected by said distance detecting portion, and

according to a predetermined data table representative of a relationship between said distance and said frequency band.

5. The endpoint device according to claim 1, wherein said band determining portion is operable to determine said frequency band on the basis of said distance detected by said distance detecting portion, and according to a predetermined data table representative of a relationship between a plurality of ranges of said distance and a plurality of frequency bands which respectively correspond to said plurality of ranges of said distance and each of which consists of a group of a plurality of mutually adjacent frequency channels, said band determining portion being operable to select, randomly or according to a predetermined rule, one of said plurality of channels of the group corresponding to one of said plurality of ranges to which the distance detected by said distance detecting portion belongs.

6. The endpoint device according to claim 1, wherein said modulating-signal generating portion is operable to generate said modulating signal in one of a plurality of time frames which is selected randomly or according to a predetermined rule.

7. The endpoint device according to claim 1, wherein said modulating-signal generating portion maintains the frequency band determined by said band determining portion, until transmission of said replying information to said interrogator is completed.

8. The endpoint device according to claim 1, further comprising a charging portion operable to charge the endpoint device with an electric energy derived from said interrogating signal, and wherein said charging portion activating the endpoint device when an amount of said electric energy stored in said endpoint device has reached a predetermined value.

9. The endpoint device according to claim 8, wherein said distance detecting portion is operable to detect said distance between said interrogator and said endpoint device, on the basis of a change of the electric energy with which the endpoint device is charged by said charging portion.

10. The endpoint device according to claim 9, further comprising a voltage detecting portion operable to detect a voltage of said charging portion, and wherein said distance detecting device detects the change of said electric energy on the basis of the voltage detected by said voltage detecting portion.

11. The endpoint device according to claim 1, wherein said distance detecting portion is operable to detect said distance on the basis of an intensity of said interrogating signal.

12. A communication system including an interrogator operable to transmit an interrogating signal containing a main carrier, and an endpoint device operable to receive the interrogating signal and respond to the interrogator with a reflected signal which is generated by modulating the main carrier with appropriate information, wherein an improvement comprises:

said interrogator including a distance detecting portion operable to detect a distance between said interrogator and said endpoint device, on the basis of an intensity of a modulating signal with which said reflected signal has been modulated in said endpoint device, said interrogator further including a distance-information transmitting portion operable to transmit to said endpoint device distance information indicative of the distance detected by said distance detecting portion; and

said endpoint device including (a) a reflecting portion operable to receive said interrogating signal containing said main carrier, and transmit said reflected signal to said interrogator, (b) an information generating portion operable to generate replying information to be transmitted to said interrogator, (c) a band determining portion operable to determine a frequency band of said modulating signal, on the basis of said distance information received from said distance-information transmitting portion, and (d) a modulating-signal generating portion operable, according to said replying information generated by said information generating portion, to generate said modulating signal having a frequency within said frequency band determined by said band determining portion.

13. A communication system including an interrogator operable to

transmit an interrogating signal containing a main carrier, and at least one endpoint device each operable to receive the interrogating signal and respond to the interrogator with a reflected signal which is generated by modulating the main carrier with appropriate information, wherein an improvement comprises:

    said interrogator including (a) a communication-condition detecting portion operable to detect a condition of communication of the interrogator with said at least one endpoint device, (b) an available-band determining portion operable to determine an available frequency band of a subcarrier signal available for said at least one endpoint device, on the basis of said condition of communication detected by said communication-condition detecting portion, and (c) a band-information transmitting portion operable to transmit to each endpoint device band information representative of said available frequency band of said subcarrier signal determined by said available-band determining portion; and

    said each endpoint device being including a frequency determining portion operable to determine a frequency of said subcarrier signal within said available frequency band represented by said band information received from said band-information transmitting portion of said interrogator.

14. The communication system according to claim 13, wherein said available-band determining portion is operable to change an upper limit of said available frequency band on the basis of said condition of communication detected by said communication-condition detecting portion.

15. The communication system according to claim 13, wherein said communication-condition detecting portion is operable to detect said condition of communication, on the basis of the number of at least one of said at least one endpoint device which has transmitted said reflected signal to said interrogator.

16. The communication system according to claim 13, wherein said communication-condition detecting portion is operable to detect said condition of communication, on the basis of at least one of a collision rate among the reflected signals transmitted from a plurality of endpoint devices,

the number of occurrences of collision among the reflected signals transmitted from said plurality of endpoint devices per unit time, and an amount of error data contained in said reflected signal transmitted from each endpoint device.

17. The communication system according to claim 15, wherein said available-band determining portion is operable to determine said available frequency band such that an upper limit of said available frequency band increases with an increase in said number of said at least one of said at least one endpoint device, which number is detected by said communication-condition detecting portion.

18. The communication system according to claim 17, wherein said available-band determining portion is operable to determine said available frequency band such that an upper limit of said available frequency band increases with an increase in said at least one of said collision rate, said number of occurrences of collision and said amount of error data, which has been detected by said communication-condition detecting portion.

19. The communication system according to claim 15, wherein said available-band determining portion is operable to determine said available frequency band such that an upper limit of said available frequency band is increased when the number of said at least one endpoint device which has been detected by said communication-condition detecting portion is equal to or larger than a predetermined first threshold value, and decreased when said number is reduced when said number is equal to or smaller than a predetermined second threshold value.

20. The communication system according to claim 17, wherein said available-band determining portion is operable to determine said available frequency band such that an upper limit of said available frequency band is increased when said collision rate, said number of occurrences of collision or said amount of error data which has been detected by said communication-condition detecting portion is equal to or larger than a predetermined first threshold value, and decreased when said collision rate, said number of occurrences of collision or said amount of error data is equal

to or smaller than a predetermined second threshold value.

21. The communication system according to claim 19, wherein said available-band determining means is operable to adjust said first and second threshold values on the basis of the number of said at least one endpoint device which has been detected by said communication-condition detecting portion.

22. The communication system according to claim 20, wherein said available-band determining means is operable to adjust said first and second threshold values on the basis of said collision rate, said number of occurrences of collision or said amount of error data which has been detected by said communication-condition detecting portion.

23. The communication system according to claim 13, wherein said available-band determining portion is operable to set an upper limit of said available frequency band at a maximum value in an initial state of the communication system.

24. The communication system according to claim 13, wherein said available-band determining portion is operable to set an upper limit of said available frequency band at a minimum value in an initial state of the communication system.

25. The communication system according to claim 13, wherein said frequency determining portion of said each endpoint device is operable to determine the frequency of said subcarrier signal, by selecting, by means of random hopping or according to a predetermined rule of hopping, one of a plurality of frequency channels set within said available frequency band determined by said available-band determining portion of said interrogator, said frequency determining portion

26. An interrogator for use in a communication system wherein each of at least one endpoint device which has received an interrogating signal containing a main carrier and transmitted from the interrogator responds to the interrogator with a reflected signal which is generated by modulating

the main carrier with appropriate information, said interrogator comprising:

a communication-condition detecting portion operable to detect a condition of communication of the interrogator with each endpoint device;

an available-band determining portion operable to determine an available frequency band of a subcarrier signal available for said at least one endpoint device, on the basis of said condition of communication detected by said communication-condition detecting portion; and

a band-information transmitting portion operable to transmit to each endpoint device band information representative of said available frequency band of said subcarrier signal determined by said available-band determining portion.

27. An endpoint device for use in a communication system wherein the endpoint device which has received an interrogating signal containing a main carrier and transmitted from an interrogator responds to the interrogator with a reflected signal which is generated by modulating the main carrier with appropriate information, said endpoint device comprising a frequency determining portion operable to determine a frequency of a subcarrier signal used by the endpoint device, within an available frequency band which has been determined by said interrogator.

28. An endpoint device for use in a communication system wherein the endpoint device which has received an interrogating signal containing a main carrier and transmitted from an interrogator responds to the interrogator with a reflected signal which is generated by modulating the main carrier with appropriate information, said endpoint device comprising:

a frequency-utilization-ratio setting portion operable to set a distribution of a frequency utilization ratio of a subcarrier signal used to modulate said main carrier, over a predetermined range of frequency of the subcarrier signal which consists of a plurality of mutually adjacent frequency channels; and

a frequency determining portion operable on the basis of the distribution of the frequency utilization ratio set by said frequency-utilization-ratio setting portion, to determine a frequency of said subcarrier signal, by random selection within said predetermined range of

frequency.

29. The endpoint device according to claim 28, further comprising a power source device, and a power-source-information detecting portion operable to detect an operating state of said power source device, and wherein said frequency-utilization-ratio setting portion is operable on the basis of the operating state of said power source device detected by said power-source-information detecting portion, to set the distribution of the frequency utilization ratio of the subcarrier signal.
30. The endpoint device according to claim 29, wherein said frequency-utilization-ratio setting portion is operable to lower a center frequency of the distribution of the frequency utilization ratio of the subcarrier signal, when a supply voltage of said power source device detected by the power-source-information detecting portion is lower than a predetermined threshold value.
31. The endpoint device according to claim 29, wherein said frequency-utilization-ratio setting portion is operable to raise a center frequency of the distribution of the frequency utilization ratio of the subcarrier signal, when a supply voltage of said power source device detected by the power-source-information detecting portion is higher than a predetermined threshold value.
32. The endpoint device according to claim 28, wherein said frequency-utilization-ratio setting portion is operable to select one of a plurality of different frequency-utilization-ratio distribution patterns each of which represents a relationship between said plurality of mutually adjacent frequency channels and said frequency utilization ratio of the subcarrier signal, said endpoint device including a memory storing data table representative of said different frequency-utilization-ratio distribution patterns, said frequency determining portion being operable to hop the frequency of the subcarrier signal according to the selected one of said different frequency-utilization-ratio distribution pattern.
33. The endpoint device according to claim 28, further comprising a power

source device, and wherein said frequency-utilization-ratio setting portion is operable to set the distribution of the frequency utilization ratio of the subcarrier signal such that a center frequency of said distribution is lower when said power source device is a primary battery cell, than when said power source device is other than said primary battery cell.

34. The endpoint device according to claim 28, further comprising a solar cell as a power source device.

35. The endpoint device according to claim 28, wherein said frequency-utilization-ratio setting portion is operable to set the distribution of the frequency utilization ratio of the subcarrier signal, by changing at least an amount of data transmitted with said reflected signal and a time period during which said reflected signal is transmitted, each time the reflected signal having a selected one of said mutually adjacent frequency channels is transmitted.

36. A communication system including an interrogator having a transmitting portion operable to transmit an interrogating signal containing a main carrier, and a plurality of endpoint devices each operable to receive the interrogating signal and respond to the interrogator with a reflected signal which is generated by modulating the main carrier with appropriate information, wherein an improvement comprises:

    said each endpoint device including (a) an individual-frequency-utilization-ratio setting portion operable to set a distribution of an individual frequency utilization ratio of a subcarrier signal used to modulate said main carrier, over a predetermined range of frequency of the subcarrier signal which consists of a plurality of mutually adjacent frequency channels, and (b) a frequency determining portion operable on the basis of the distribution of the individual frequency utilization ratio set by said individual-frequency-utilization-ratio setting portion, to determine a frequency of said subcarrier signal, by random selection within said predetermined range of frequency;

    said interrogator including (i) an overall-frequency-utilization-ratio determining portion operable to determine a distribution of an overall frequency utilization ratio of the reflected signal received from said plurality

of endpoint devices, and (ii) a switching-information generating portion operable on the basis of the distribution of said overall frequency utilization ratio determined by said overall-frequency-utilization-ratio determining portion, to generate switching information on the basis of which said individual-frequency-utilization-ratio setting portion of said each endpoint device sets the distribution of said individual frequency utilization ratio of the subcarrier signal;

    said transmitting portion of said interrogator being operable to transmit said interrogating signal containing said main carrier and said switching information generated by said switching-information generating portion; and

    said individual-frequency-utilization-ratio setting portion being operable to set the distribution of said individual frequency utilization ratio of the subcarrier signal of said each endpoint device, on the basis of said switching information generated by said switching-information generating portion.

37. The communication system according to claim 36, wherein said switching-information generating portion is operable to generate the switching information for raising a center frequency of the distribution of said individual frequency utilization ratio of the subcarrier signal of said each endpoint device, when said overall-frequency-utilization-ratio determining portion determines that said overall frequency utilization ratio of said reflected signals in relatively low frequency channels of said predetermined range of frequency of the subcarrier signal is higher than a predetermined threshold value.

38. The endpoint device according to claim 36, wherein said switching-information generating portion is operable to generate the switching information for lowering a center frequency of the distribution of said individual frequency utilization ratio of the subcarrier signal of said each endpoint device, when said overall-frequency-ratio-ratio determining portion determines that said overall frequency utilization ratio of said reflected signals in said predetermined range of frequency of the subcarrier signal is lower than a predetermined threshold value.

39. A communication system including an interrogator having a transmitting portion operable to transmit an interrogating signal containing a main carrier, and a plurality of endpoint devices each operable to receive the interrogating signal and respond to the interrogator with a reflected signal which is generated by modulating the main carrier with appropriate information, wherein an improvement comprises:

    said each endpoint device including (a) an individual-frequency-utilization-ratio setting portion operable to set a distribution of an individual frequency utilization ratio of a subcarrier signal used to modulate said main carrier, over a predetermined range of frequency of the subcarrier signal which consists of a plurality of mutually adjacent frequency channels, (b) a frequency determining portion operable on the basis of the distribution of the individual frequency utilization ratio set by said individual-frequency-utilization-ratio setting portion, to determine a frequency of said subcarrier signal, by random selection within said predetermined range of frequency, (b) a power source device, and (c) a power-source-information detecting portion operable to detect supply-voltage information indicative of a suppl. voltage of said power source device,

    said interrogator including (i) an overall-frequency-utilization-ratio determining portion operable to determine a distribution of an overall frequency utilization ratio of the reflected signal received from said plurality of endpoint devices, (ii) an endpoint-device monitoring portion operable on the basis of said supply-voltage information received from said power-source-information detecting portion, to determines one of a plurality of predetermined supply voltage ranges in which the supply voltage of said power source device detected by said power-source-information detecting portion of said each endpoint device falls, and (iii) a switching-information generating portion operable on the basis of the distribution of said overall frequency utilization ratio determined by said overall-frequency-utilization-ratio determining portion, and a result of determination by said endpoint-device monitoring portion, to generate switching information on the basis of which said individual-frequency-utilization-ratio determining portion of said each endpoint device sets the distribution of said individual frequency utilization ratio of the subcarrier signal;

said transmitting portion of said interrogator being operable to transmit said interrogating signal containing said main carrier and said switching information generated by said switching-information generating portion; and

said individual-frequency-utilization-ratio setting portion being operable to set the distribution of said individual frequency utilization ratio of the subcarrier signal of said each endpoint device, on the basis of said switching information generated by said switching-information generating portion and said supply-voltage of said power source device detected by said power-source-information detecting portion.

40. The communication system according to claim 39, wherein said switching-information generating portion is operable to generate the switching information for raising a center frequency of the distribution of said individual frequency utilization ratio of the subcarrier signal of said each endpoint device, when said overall-frequency-utilization-ratio determining portion determines that said overall frequency utilization ratio of said reflected signals in relatively low frequency channels of said predetermined range of frequency of the subcarrier signal is higher than a predetermined threshold value.

41. The endpoint device according to claim 39, wherein said switching-information generating portion is operable to generate the switching information for lowering a center frequency of the distribution of said individual frequency utilization ratio of the subcarrier signal of said each endpoint device, when said overall-frequency-ratio-ratio determining portion determines that said overall frequency utilization ratio of said reflected signals in said predetermined range of frequency of the subcarrier signal is lower than a predetermined threshold value.

42. The endpoint device according to claim 39, wherein said plurality of endpoint devices include at least one first endpoint device wherein a primary battery cell is provided as said power source device, and at least one second endpoint device wherein a secondary battery cell is provided as said power source device, said switching-information generating portion being operable to generate the switching information that causes said

individual-frequency-utilization-ratio setting portion of each of said at least one first endpoint device to set the distribution of said individual frequency utilization ratio of the subcarrier signal such that a center frequency of the distribution of said individual frequency utilization ratio of the subcarrier signal of said each first endpoint device is lower than that of said each second endpoint device.

43. An interrogator for use in a communication system wherein a plurality of endpoint devices which have received an interrogating signal containing a main carrier and transmitted from the interrogator respond to the interrogator with respective reflected signals which are generated by modulating the main carrier with appropriate information, said interrogator comprising:

an overall-frequency-utilization-ratio determining portion operable to determine a distribution of an overall frequency utilization ratio of the reflected signals received from said plurality of endpoint devices;

a switching-information generating portion operable on the basis of the distribution of said overall frequency utilization ratio determined by said overall-frequency-utilization-ratio determining portion, to generate switching information on the basis of which said each endpoint device sets a distribution of an individual frequency utilization ratio thereof; and

a transmitting portion operable to transmit said interrogating signal containing said main carrier and said switching information generated by said switching-information generating portion.

44. An interrogator for use in a communication system wherein a plurality of endpoint devices which have received an interrogating signal containing a main carrier and transmitted from the interrogator respond to the interrogator with respective reflected signals which are generated by modulating the main carrier with appropriate information, said interrogator comprising:

an overall-frequency-utilization-ratio determining portion operable to determine a distribution of an overall frequency utilization ratio of the reflected signals received from said plurality of endpoint devices;

an endpoint-device monitoring portion operable on the basis of supply-voltage information which has been received from each of said

endpoint devices and which is indicative of a supply voltage of said each endpoint device, to determine one of a plurality of predetermined supply voltage ranges in which the supply voltage of said each endpoint device falls;

a switching-information generating portion operable on the basis of the distribution of said overall frequency utilization ratio determined by said overall-frequency-utilization-ratio determining portion, and a result of determination by said endpoint-device monitoring portion, to generate switching information on the basis of which said each endpoint device sets a distribution of an individual frequency utilization ratio thereof; and

a transmitting portion operable to transmit said interrogating signal containing said main carrier and said switching information generated by said switching-information generating portion.